Savannah River Remediation

We do the right thing.

Improved Modular CSSX Unit (MCU) Operations

Presentation to:

EM Waste Processing Technical Exchange

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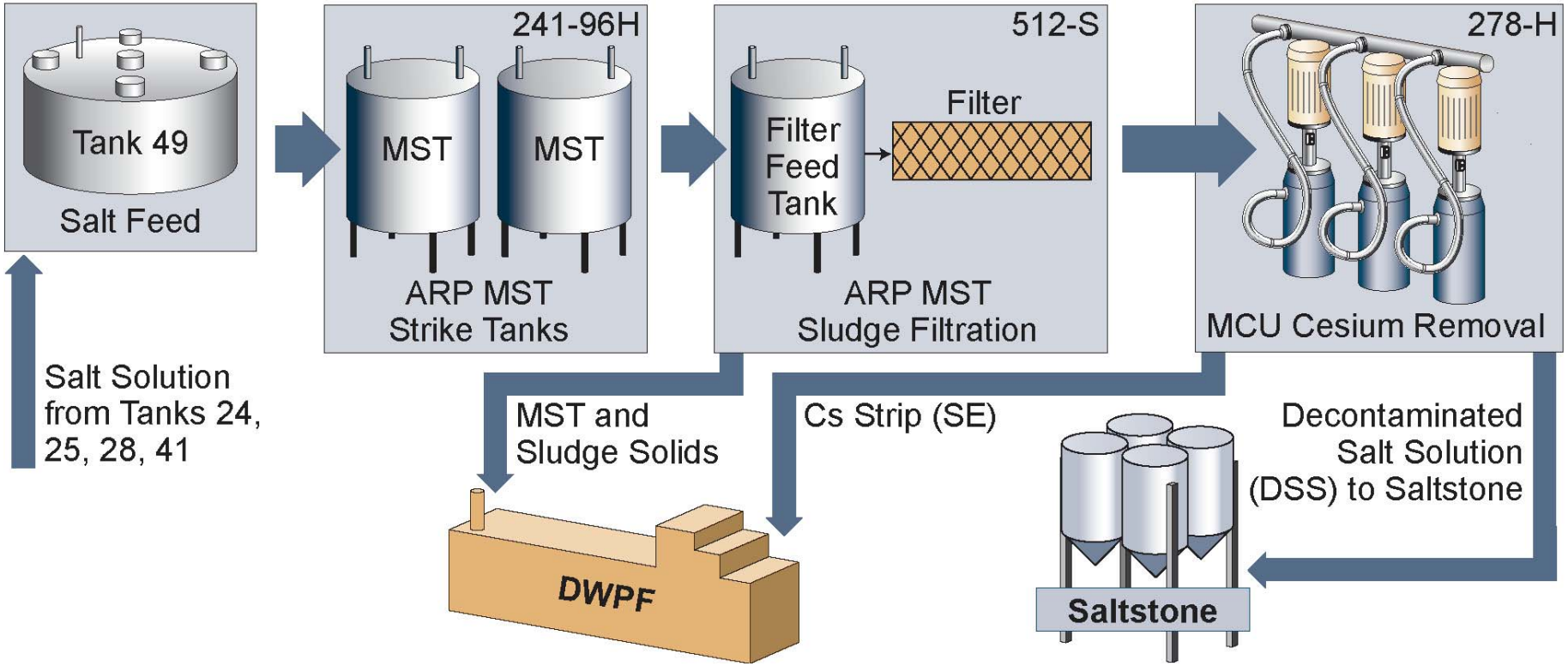
Overview

- Actinide Removal Process/Modular Caustic Side Solvent Extraction Unit (ARP/MCU)
  - Objectives of ARP/MCU
  - MCU Current Performance
  - MCU Improvements
- Next-Generation Solvent (NGS) at MCU
  - Parallel R&D / Engineering
  - Flowsheet Integration

ARP/MCU


Tank 49
Salt Feed
241-96H
MST
MST
ARP MST
Strike Tanks
512-S
Filter
Feed
Tank
Filter
ARP MST
Sludge Filtration
278-H
MCU Cesium Removal
Salt Solution
from Tanks 24,
25, 28, 41
MST and
Sludge Solids
Cs Strip (SE)
Decontaminated
Salt Solution
(DSS) to Saltstone
DWPF
Saltstone

ARP / MCU Objectives

- Using a “first of a kind” process for salt treatment
  - Provide lessons learned to SWPF design
  - Treat Salt Solution (< 200,000 Ci of Cs) prior to the start of SWPF with a ramp-up in process & equipment performance as lessons learned are incorporated
- Provide life extension and NGS as part of supplemental salt initiative

MCU Performance

Management of key radionuclide decontamination has been demonstrated:

	Expected	Actual
Cs-137 DF	>12	>200
MCU CF	12-15	12-15

Management of organic carryover in progress:

Decontaminated Salt Solution Carryover	<50 ppm	<25 ppm avg
Strip Effluent Carryover	<50 ppm	<25 ppm avg

Ability to achieve sustained high throughput in progress:

- Increased salt throughput from 4 gpm to 6 gpm
- Achieved 45k gallons throughput in a week
- Continue efforts to improve attainment for a first-of-a-kind facility

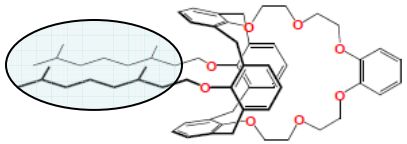
MCU Process Enhancements

- Attainment & Capacity
  - Chemically adjusted feed
  - Increased salt feed flow rate to 6 gpm in MCU
  - Improved MCU sample configuration, reduced cross contamination
  - Blend tank / Salt dissolution receipt tank
- Optimization & Reliability
  - Automated MCU process startup
  - Upgraded first MCU process pump system
  - Implemented solvent material balance feedback indicators and predictive adjustments

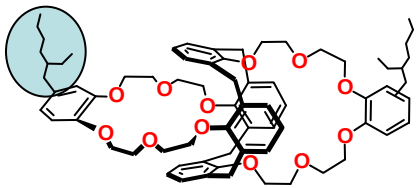
ARP/MCU Life-Extension

- **Enhance Performance**: Next Generation Solvent (NGS) resolves constraints of current extractant (BOBCalix):
  - Solubility
    - NGS: 50mM
    - Current: 7mM
  - 5X stronger Cs extraction
  - Enhanced stripping methodology
  - Performance improved to increase instantaneous throughput
- Demonstrate technology applicable to SWPF
- Fewer curies sent to Saltstone Disposal Facility than with current flowsheet

- **Extend Operations**
  - Provide flexibility to continue processing salt waste
  - Increase reliability to increase throughput to 2Mgal/yr
  - Improve filtration cycle
  - Improve sampling
  - Improve solvent control



MAXCalix



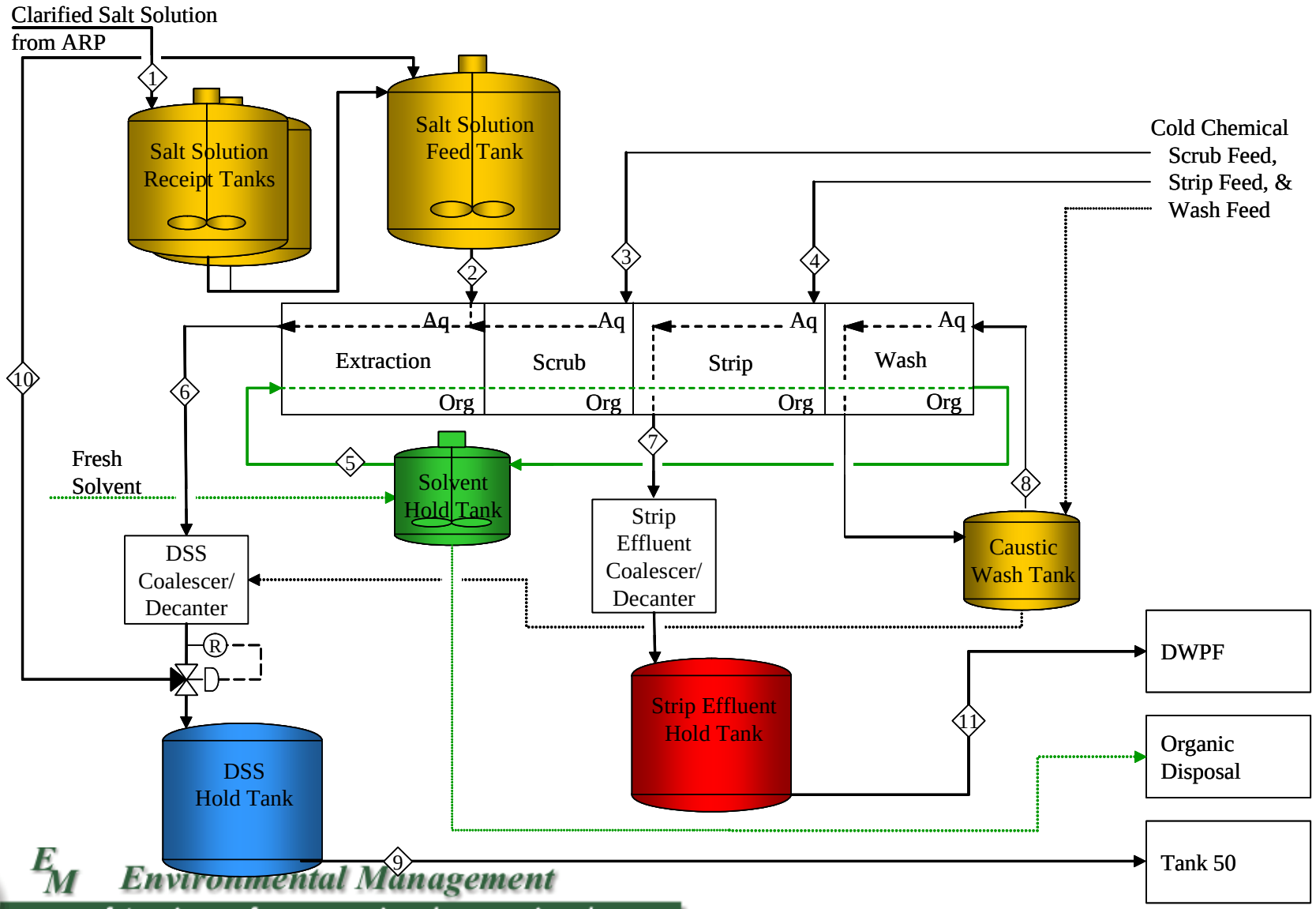
e.g. BEHBCalix

- **Substitution of groups remote from Cs^+ ion binding site**
- **Enhanced scrub/strip methodology**
- **Combination of increased solubility and enhanced stripping methodology yields much higher DF**

NGS Deployment

- Integrated technology development and deployment team: DOE EM-30, DOE-SR, SRR, SRNL, ORNL, ANL
- R&D/Testing
  - Solvent Radiation Stability Testing
  - Lab Scale ESS Testing
  - Real Waste Bench Scale Flowsheet Testing
  - Full Scale Contactor Hydraulic & Mass Transfer Testing
  - Coalescer Performance Validation
- Engineering
  - MCU Flowsheet Engineering
  - Flowsheet Integration: DWPF
    - Glass Formulation Studies
    - Melter Testing
    - Chemical Process Cell (CPC) Flowsheet Demonstration

MCU-NGS Process Engineering



Cold Feed Chemicals

Cold Chemical		Concentration
Scrub	*Current*	0.050 M Nitric Acid, HNO_3
	NGS	0.025 M Sodium Hydroxide, NaOH
Strip	*Current*	0.001 M Nitric Acid, HNO_3
	NGS	0.010 M Boric Acid, H_3BO_3
Wash	*Current*	0.010 M Sodium Hydroxide, NaOH
	NGS	0.001 M Sodium Hydroxide, NaOH
Solvent	*Current*	0.750 M Cs-7SB 0.007 M BoBCalix 0.003 M TOA ISOPAR-L® balance
	NGS	0.500 M Cs-7SB 0.050 M MaxCalix 0.003 M LIX 79 ISOPAR-L® balance

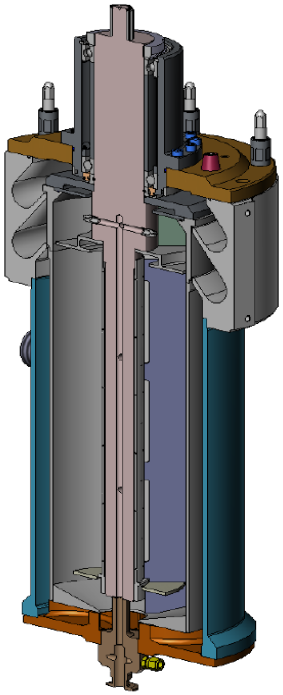
Scrub & strip receipt tanks require cleaning: Guanidine not compatible with HNO_3.

Salt Solution Feed

- **Clarified Salt Solution from ARP**
  - High molarity sodium (4 - 7 M)
  - Low molarity potassium (<45 mM)
  - Actinides & strontium removed by MST strike
  - Cs-137 ≤1.1 Ci/gal
  - Held in 6300 gallon agitated Salt Solution Receipt & Feed Tanks
- **MCU Throughput**
  - Current flowrate: 3.5-8.5 gpm
  - NGS flowrate: 3.5- up to an instantaneous 12 gpm

No feed changes required.

Contactor Bank



CINC Centrifugal Contactor

- **Extraction**: 7 V-10
- **Strip**: 7 V-05
- **Scrub**: 2 V-05
- **Wash**: 2 V-05

Extraction

Stream		Density (mg/mL)	Flowrate (gpm)	T (°C)	Cs-137 (Ci/gal)	Composition
Solvent	*Current*	0.855	1.17 – 2.83	23 ± 3	<0.34	BobCalix Extractant
	NGS	0.828	1.17 – 3.00	23 ± 3	<0.001	MaxCalix Extractant

- **Cesium Distribution Ratios**
  - NGS 5X stronger extraction
    - Decontamination factor
      - NGS (>40,000)
      - Current (≥12)
- **V-10 Contactors**
  - Heavy-phase weir
    - 5.1" diameter
- **Organic:Aqueous Ratios**
  - NGS- 1:4
  - Current- 1:3
- **Throughput**
  - 40% increase in maximum salt solution feed rate
  - 6% increase in maximum solvent flow rate

No extraction section changes required.

Scrub & Strip

Stream		Flowrate (gpm)	Composition
Scrub Feed	*Current*	0.23 – 0.57	0.05 M Nitric Acid
	NGS	0. 23 – 0.80	25 mM Sodium Hydroxide
Strip Feed	*Current*	0.23 – 0.57	0.001 M Nitric Acid
	NGS	0.23 – 0.80	10 mM Boric Acid

- **Scrub Cesium Distribution Ratios**
  - NGS D_{Cs} ~2X Bob solvent
  - More K^+ scrubbed from solvent
- **Scrub Organic:Aqueous Ratio**
  - NGS- 3.75 : 1
  - Current- 5 : 1
- **NGS >50X stronger strip**
- **Throughput**
  - 12% increase in maximum total throughput
    - NGS- 3.8 gpm
    - Current- 3.4 gpm
- **Contactor Heavy-phase Weirs**
    - NGS- 2.7” diameter
    - Current- 2.6” diameter

Weir change required in scrub & strip sections.

Wash

Stream		Flowrate (gpm)	Composition
Wash Solution	*Current*	0.23 – 0.57	0.01 M Sodium Hydroxide
	NGS	0.23 – 0.80	0.01 M Sodium Hydroxide

- Removes process degredation products
- Feed & Bleed to maintain pH

- V-05 Contactors
  - Heavy-phase weir
    - NGS- 2.7” diameter
    - Current- 2.6” diameter

Weir change required in wash section.

Outlet Streams

Stream		Flowrate (gpm)	Cs-137 (Ci/gal)
Decontaminated Salt Solution (DSS)	*Current*	3.5 – 8.5	≤ 0.18
	NGS	3.5 – 12	≤ 2.75 E-5
Cs Concentrated Strip Effluent (SE)	*Current*	0.23 – 0.57	≤ 16.5
	NGS	0.23 - 0.80	≤ 16.5

- Streams pass through coalescers to increase organic droplet size large enough to decant.
- Decant solvent from aqueous streams

No outlet stream changes required.

MCU Modifications

- Clean strip and scrub storage tanks
  - Nitric acid from current flowsheet not compatible with guanidine in NGS flowsheet
- Change heavy-phase weirs in V-05 contactors
  - Hydraulic model shows changes needed because of lower solvent density (0.826 mg/l vs. (0.855 mg/l)
- Move coalescers to more accessible position
  - Ability to remotely remove and replace
- Change Distributed Control System software to reflect new flowsheet
- Develop on-line solvent analysis technology
  - DSSHT
  - SEHT

Summary

- MCU continues to optimize process
- Throughput has increased from 4 gpm to 6 gpm
- Attainment is improving through equipment enhancements and monitoring
- Measures to reduce risk are continually implemented
- Lessons Learned are provided to SWPF
- Demonstration of technology applicable to SWPF

Presenter Information

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Weir change reasoning

Extraction	Solvent Density (mg/mL)	Salt Density (mg/mL)	Difference
Current	0.855	1.15 – 1.3	0.295 – 0.445
Next Generation	0.826	1.15 – 1.3	0.324 – 0.474

Scrub/Strip/ Wash	Solvent Density (mg/mL)	Cold Feed (mg/mL)	Difference
Current	0.855	1.00	0.145
Next Generation	0.826	1.00	0.174